Chapter 4

Space System Capabilities and Limitations

This chapter addresses the capabilities of space systems without regard to their general application in an operational setting as was done in Chapter 3. Here, they are considered within the major functional areas of communications, reconnaissance, intelligence, surveillance, and target acquisition, weather, terrain, and environmental monitoring, position and navigation, and missile warning. These capabilities reinforce the importance of space systems as force multipliers, increasing the effectiveness and efficiency of the force. The advantages gained through the use of space systems are vital and integral to the success of any Army operation; however, the limitations associated with the use of space systems must also be considered.

SYSTEM CAPABILITIES

Space system capabilities increase the effectiveness and efficiency of Army forces, whether training, supporting MOOTW, or conducting combat operations. Army planners must optimize the use of space capabilities to enhance land operations. Generally, the CINC, or in the case of most contingency operations, the Army service component commanders (ASCCS), develop operational requirements and then forward them to the Department of the Army staff for resolution. Requirements vary, depending on the specific area of operations, the mission, the maturity of the theater, and the situation. However, space systems may satisfy many of these requirements. The CINC, through apportionments from the JCS, decides what space support is available or can be made available to the ASCC. Generally, space capabilities enhance the Army's ability to-

- Accurately assess the current situation.
- Adapt to the demands of the situation, that is, to modify plans.
- Anticipate enemy actions.
- Act and react faster than the enemy.
- Exploit opportunities and enemy vulnerabilities.
- Identify targets for fire support systems.
- Command and control its forces.
- Maximize use of terrain.

However, access to and availability of space capabilities depend to a degree on the echelon of command. The staff's responsibility is to know what capabilities are available and to optimize them. As forces are tailored to satisfy mission requirements, space system user terminals may have to be redistributed and space support teams created. To ensure adequate space support for the deploying force, a USARSPACE ARSST can form the nucleus of a tailored space support team.

Each space system consists of three segments: a space segment—the satellites; a control segment—ground control stations and managers; and a user segment—the equipment necessary to receive the satellite signals (see Figure 4-1). Following is a general discussion of space systems and associated terminals available to support the Army.

COMMUNICATIONS

High ground has always played an important role in effective military communications, Communicating with forces dispersed across the battlefield or deployed great distances from their home bases has always been a major challenge. The importance of communications increases as the Army's mission becomes more complex and force levels decrease. Combat net radios for ultrahigh frequency (UHF) and very high frequency (VHF) are limited by line of sight (LOS) and have to rely on radio relays located on high ground to overcome terrain restrictions. Satellite communications systems are less hampered by LOS restrictions and can significantly enhance Army communications capabilities by extending ranges and reliability. Satellites offer an effective means of overcoming the physical limitations of LOS radios, extending the range of terrestrial communications systems, such as MSE, throughout the area of operations.

Communications satellites are the cornerstone of the Army's battle command architecture. They operate in a wide band of radio frequencies and provide the link between theater and CONUS for split-based operations and range extension between subordinate commands in the theater (see Figure 4-2). UHF satellite communications systems, such as the FLTSAT and AFSATCOM systems, are used to support battle command requirements for high-priority users, to include EAM dissemination, force direction, and JCS/CINC netting. SHF communications systems, such as the DSCS, support worldwide, long-haul, secure-voice and high-data-rate communications for battle command, early warning, crisis management, and internetting between the NCA/JCS and the combatant commanders. Milstar, the next

Figure 4-1. Space System Segments

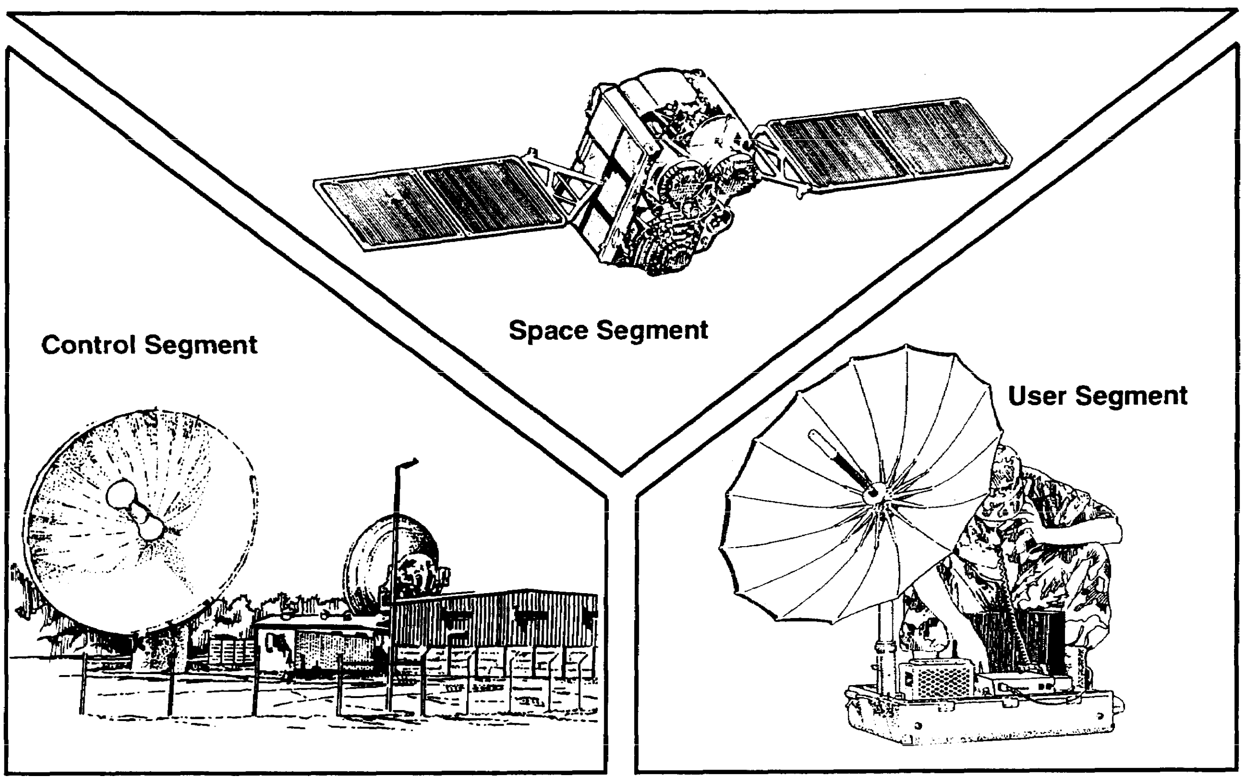
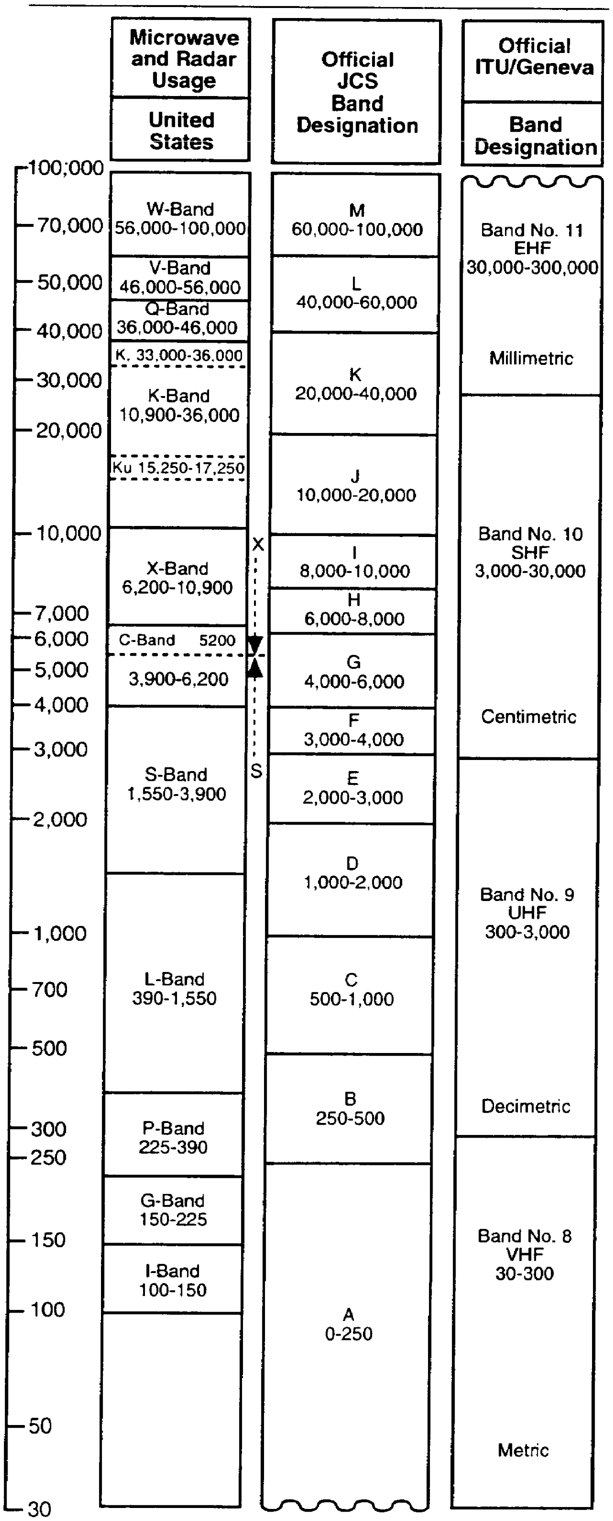


Figure 4-2. Satellite Communication Frequency Band



All Frequencies in Megahertz

generation military satellite communications system, is an EHF system capable of jam-resistant secure worldwide communications during all levels of conflict.

The modern battlefield is volatile and requires synchronization of operations throughout its depth. Success on the battlefield demands flexible, highly mobile, responsive, reliable, secure, jam-resistant, and survivable communications, unhindered by terrain masking or other LOS constraints. Currently, satellites are used primarily to augment ground-based communications systems, providing communications links not only to forces employed in an area of responsibility, but also to deploying forces while en route. However, during deployments to contingency areas having little or no infrastructure to support command and control, satellites will become the primary means of communications. Satellite communications provide the following advantages, which make them ideal for force projection operations:

- Greater freedom from siting restrictions.
- Extended range, capacity, and coverage.
- Real-time and store-and-forward capabilities.
- Stand-alone capability and reduced logistical support on the battlefield.
- Freedom from rigid network configurations.
- Mobility and rapid emplacement.
- Extremely high circuit reliability.

Military and commercial satellite communications systems are invaluable assets that can be used at all echelons of command. Military battle command nets are usually routed through military satellites due to the low probability of intercept and the increased communications capability (for example, to pass higher data rates and imagery) that they afford. Administrative and logistics networks may use either military or commercial satellites, which routinely support force projection and split-based operations around the world. These same systems may also be available to support selected training exercises. Military satellite communications systems, however, are considered joint assets and are controlled by the JCS, who allocate the resources based on need. JCS Memorandum of Policy 37 specifies access priorities. More often than not, demand exceeds the capabilities of the systems; therefore, access to military satellite channels is at a premium and closely monitored. Consequently, Army forces must clearly define and articulate their requirements for critical battle command connectivity. The Army also must consider the use of commercial satellites, such as the INTELSAT and the INMARSAT terminals, as an alternative means of satisfying their communications requirements. Space is not the panacea for all communications shortfalls; however, it is an important element of the flexible, responsive, and integrated battle command system required for Army operations.

POSITION AND NAVIGATION

The NAVSTAR GPS satellite is a space-based, all-weather, continuous-operation radio navigation system that provides military users highly accurate worldwide position and location data, as well as velocity information and precision time. While GPS receivers do not replace the map and compass or some of the other navigation systems currently available, these lightweight man-portable systems satisfy more of the Army's requirements than other available systems. GPS receivers provide the soldier much useful information, such as positioning and timing data; however, some other advantages to using the GPS are equally significant:

- First, because GPS receivers do not transmit any signals, they are not electronically detectable.
- Second, the number of simultaneous GPS users is unlimited.
- Third, although the accuracy of GPS is subject to certain influences, it does not vary over time as does the accuracy of inertial navigation aids. Ongoing technical refinements promise to strengthen the robustness and reliability of the GPS signal. GPS can quickly regain precision accuracy after momentary disruptions without further operator actions.

GPS greatly improves the commander's ability to locate units and to control them on the battlefield, facilitating situational awareness and improving agility and the ability to synchronize forces. GPS receivers increase the ability to accurately locate assets and to move them long distances over difficult terrain, especially during poor weather or lighting conditions. The GPS, when used in conjunction with maps or image products, can assist in all-weather, day-or-night rendezvous at designated points and times under radio silence. Accurate positioning data on friendly troops and on the location of minefield emplaced by friendly units can simplify the passage of lines and reduce fratricide.

GPS output can be in any one of the three commonly used coordinate systems: geographic, universal transverse mercator, or military grid reference. Joint and combined operations benefit from a common user grid. This grid allows units to use their specific coordinate position system and then to convert it rapidly to common coordinates or into similar systems used by other services or nations. Common positioning also reduces the minimum separation distance requirements for artillery, naval fire support, or close air support. The GPS's inherent accuracy increases the accuracy of requested fires, reducing the expenditure of ammunition as well as the risk of casualties caused by friendly fire.

The commander can also use GPS to manage critical assets that support the battle, to include weapon convoys, fuel, and ammunition supply points. The true value of POS/NAV equipment is that, for the first time, ground forces have access to small, lightweight navigational tools—that is, the SLGR and its replacement, the PLGR, AN/PSN-1l—that are capable of providing very accurate information. This capability can provide POS/NAV information under most terrain and weather conditions. It will also profoundly influence azimuth determination, air traffic control, munitions guidance, and gun-laying operations.

The Army also has a limited number of commercial off-the-shelf (COTS) geodetic-quality receivers that provide positioning accuracies within millimeters. While engineers primarily use these systems to support terrain analysis and mapping requirements, they can also be used to support battle command and targeting. The cost and the necessity for specially trained operators limit the use of these receivers.

RECONNAISSANCE, INTELLIGENCE, SURVEILLANCE, AND TARGET ACQUISITION

Space-based sensors have the advantage of unrestricted access over battlefields and other areas that are difficult to observe due to political or military reasons. Space systems allow the commander to see his area of operations and battle space, often far better than terrestrial systems, and permit near-real-time exploitation of favorable situations. This capability improves the agility, flexibility, and synchronization of the force-important aspects of current Army doctrine. Commanders can receive deep operations information as quickly and as accurately as close operations information. When information derived from space-based RISTA sensors is merged with information from ground and airborne systems through the ASAS, IPB is enhanced, situational awareness improved, and uncertainty reduced.

The Army's TENCAP Program, as executed by the ASPO, focuses on tactical applications of national space systems. The program provides Army commands with equipment (see Figure 4-3) that can receive and process data from these systems. The result has been the development and fielding of limited production equipment as operational systems that provide a valuable adjunct to organic sensors.

The commander benefits from access to data on enemy troop movements, lines of communications, and terrain conditions. He can use such information to determine the enemy's intent through direction and mass of enemy movement. The favored avenues of approach and the direction of the main attack can point to the most effective time and location for targeting friendly fires. Such information also offers opportunities for target damage assessment after deep attack by fire. See The Joint Tactical Exploitation of National Systems (J-TENS) manual for further information on the TENCAP Program and system capabilities. The J-TENS manual contains the procedures tactical commanders follow to obtain TENCAP support.

MISSILE DEFENSE

The DSP offers an early warning missile surveillance capability during operations. The DSP satellite constellation recognizes the launch of strategic and certain tactical missiles using infrared sensors to detect heat from missile plumes. Warning information consists of an assessment of the time and place of launch, the type of missile launched, and the missile's estimated course/direction. This information is provided to supported CINCs via voice and data communications. SATCOM is used to disseminate voice warning, and the TERS is used for data. The TERS is a worldwide distribution system currently made up of the Tactical and Related Applications (TRAP), Tactical Information Broadcast Service (TIBS), and Joint Operation Tactical System Communications Network. This launch warning data is communicated to Army forces within a theater to support TMD operations. Today, warning information is both centrally processed in CONUS and transmitted to the user via JTAGS prototypes that are actively serving tactical users with direct in-theater downlinks today. They will be replaced by van-mounted objective systems in the near future.

WEATHER, TERRAIN, AND ENVIRONMENTAL MONITORING

Detailed analysis of the environment, that is, weather and terrain, is a critical step in the IPB process. Weather and terrain conditions impact on friendly and enemy capabilities to move, shoot, and communicate. To optimize the capabilities of modern weapons systems, the tactical commander requires real-time weather and terrain information about his battle space. Satellites with weather and terrain monitoring

Figure 4-3. Equipment That Can Receive and Process TENCAP Data

SYSTEM	MOBILITY	PROCESS	PRODUCT	COMMUNICATIONS
ETUT	C-130	CORRELATE/INTEGRATE ANALYSIS/RAPID REPORTING/COLL MGT 4 WORKSTATIONS	INTEL REPORTS ANNOTATED IMAGERY TARGET DATA TASKING DATA	SUCCESS/AUTODIN TROJAN/STU-III MSE CK
EPDS	C-130	CORRELATE/INTEGRATE ANALYSIS/RAPID REPORTING/REAL TIME DDL/2 WORKSTATIONS	INTEL REPORTS TARGET DATA	SUCCESS/AUTODIN TROJAN/STU-III MSE CK S-BAND SATCOM SOURCE DL
MIES	C-141 C-5A LIMITED	NATIONAL/THEATER IMAGERY	INTEL REPORTS ANNOTATED IMAGERY TARGET DATA	SUCCESS/AUTODIN TROJAN/STU-III DSCS
ETRAC	C-141 C-130	NATIONAL/THEATER IMAGERY	INTEL REPORTS ANNOTATED IMAGERY TARGET DATA	SUCCESS/AUTODIN TROJAN/STU-III MSE CK/SOURCE DL CTT-H
MITT	C-130 RAPID RO/RO HMMWV (2 EA)	ETUT PROCESSES EXCEPT COLL MGT 2 WORKSTATIONS	INTEL REPORTS ANNOTATED IMAGERY TARGET DATA	SUCCESS AUTODIN TROJAN/STU-III MSE CK/SOURCE DL
FAST	RAPID 7 CASES	SECONDARY IMAGERY SIGNAL DATA	INTEL REPORTS ANNOTATED IMAGERY TARGET DATA	SUCCESS/AUTODIN TROJAN/STU-III MSE CK/DSCS
SUCCESS	SAME AS THE ASSOCIATED PLATFORM	UHFSATCOM TRANSCVR FOR TADIX-B/STRAP/SID	SIMULTANEOUS RCV/XMIT RADIO	2 CONFIGURATIONS 2 RCV/1 XMIT OR 2 RCV/2 XMIT
CHARIOT	RAPID	S-BAND	RCV/XMIT	SUCCESS/DSN TROJAN/STU III MSE CK MZZ
CTT-H	SAME AS THE ASSOCIATED PLATFORM	UHF SATCOM AND AIRBORNE RELAY TRANSCVR FOR TADIXS-B/TRAP/TIBS/SID/ TRIXS	SIMULTANEOUS RCV/XMIT, W/EMBEDDED COMSEC	2 CONFIGURATIONS 3 RCV/1 XMIT W/MDX SECURE VOICE 3 RCV ONLY

sensors are a vital component in the information collection system. Weather and terrain information must be collected and downlinked to a ground processing unit where it can be used to prepare tailored products to support decision making by tactical commanders.

Weather

Military and civil weather satellites provide worldwide, near-real-time weather information. DMSP satellites obtain comprehensive information on weather phenomena and atmospheric data. They can image weather phenomena in both visual and infrared spectral bands. Simultaneously, they record the temperature and moisture data throughout the swath width and at various altitudes. Large DMSP receiver systems, known as Air Force Mark IV vans, normally deploy to rear areas in mature theaters where they receive data and relay products to corps and division SWOs via facsimile. There it is analyzed and combined with other local weather information that may be received through the IMETS to forecast conditions throughout the battle space.

Civil geostationary satellites such as the GOES provide a hemispherical view of weather patterns, while polar-orbiting satellites, such as the television infrared observation satellite (TIROS), provide a low earth view of the weather as they pass overhead. Wraase weather receivers receive weather facsimile (WEFAX) and automatic picture transmission images from US, Russian, Japanese, and European civil weather satellites. They do not receive DMSP or other data, for example, atmospheric temperatures and moisture content, transmitted by civil satellites. Using the Wrasse weather receiver to exploit near-real-time satellite-gathered weather data and making it available down to division level has significantly improved forecasting at the tactical level of operations. The public and private sectors have jointly made great advances in exploiting space technologies, resulting in the rapid accumulation and dissemination of weather data in immediately usable form to Army forces.

Terrain

Understanding the limitations and opportunities of terrain is a fundamental military skill. Terrain forms the natural structure of the battlefield. Commanders must recognize the its drawbacks and potential to protect friendly operations and to put the enemy at a disadvantage. Terrain analysis is critical to current and projected operational uses of specific terrain.

Much of the world is not adequately mapped to support Army operations. Satellites collecting MSI can provide reasonably accurate, medium-resolution data (see Figure 4-4) to aid in mapping and terrain analysis. The DMA and some engineer topographic (TC)PO) units can create MSI maps primarily to be used as map substitutes in areas of the world that are not adequately mapped to large scale. Satellite image mapping capabilities can provide the most current data worldwide. Terrain-sensing satellites using MSI can provide accurate 5-to-80 -meter-resolution terrain data to support mapping and other analytical requirements. In the near future, satellites will be capable of providing HSI data that will further enhance map-producing capabilities.

The Army may establish purchasing accounts through the DMA to obtain MSI/HSI data from sources outside the US, such as data from France's SPOT earth resources satellite or Japan's MOS-1. This data will normally be delivered to the requesting unit. The primary source of data for Army units is collected with the earth imaging satellite Landsat, which is channeled through the DMA through theater mapping, charting, and geodesy channels. However, several other Army organizations (Topographic Engineering Center [TEC] and USARSPACE) have been funded to procure Landsat imagery. DOD involvement in the Landsat program and the creation of a worldwide data base will vastly increase the availability and use of MSI data within DOD. Using digital map data as a base, satellite images can be fused to provide information, often only days old, that is invaluable to commanders. Today, the Army's organic MSI manipulation and analytical capabilities are just getting established. The ARSST at USARSPACE is equipped and trained to bring COTS processors with these capabilities to deploying units. Topographic support teams at the corps and division levels manipulate MSI data using these processors. These products can be used to support military engineering requirements and IPB by identifying—

- Vegetation characteristics--cover and concealment.
- Soil characteristics,
- Snow/ice characteristics.
- Fording locations—water depth.
- Landing/drop zones.
- Lines of communications.
- Energy resources/facilities.
- Lodgment areas.
- Enemy fortifications.
- Urban and cultural features

Environmental Monitoring

Merging MSI data with digital TOPO data and digital terrain elevation data produced by the DMA provides three-dimensional perspective views. These views highlight observation and

Figure 4-4. MSI and Radar Satellite Characteristics

SATELLITE	NATION	SENSOR	MODE	ALTITUDE (KM)	GROUND RESOLUTION (METERS)	SWATH WIDTH (KM)	REPEAT CYCLE (DAYS)	FREQ BANDS
NOAA	USA	AVHRR	MSI	833	1,100	2,400	0.5	5
LANDSAT	USA	MSS TM	MSI MSI	705	80 30	185 185	16 16	4 7
MOS	JAPAN		MSI	909	50	100	17	4
SPOT	FRANCE	HRV	MSI Panchromatic	832	20-30 10	60 60	26 26	3 1
RESURS-O	RUSSIA	CCD Conical Microwave	MSI MSI MSI	625	45 240 17-90	350 600 1,200	14 14 14	3 5 4
RESURS-F	RUSSIA	Photo	MSI	270	5-8	150	2 passes before deorbit.	3
IRS-1B	INDIA	LISS Scanner 1 LISS Scanner 2	MSI MIS	900	72 32	120 120	16 16	4 4
ERS-1	ESA	Altimeter Synthetic Aperture Scatterometer	Radar Radar Radar	675	0.5 (alt) 30 2 m/sec	80 80 80	3 3 3	1 1 1

fields of fire from both the aerial and ground perspectives. A rough analysis of these images will show potential ingress and egress routes and aid in the development of trafficability assessments. This information could include soil trafficability, mobility corridors, and perspective views of denied areas, including enemy-controlled territory, contaminated areas, minefields, smoke, forest fires, and many other conditions that may arise in the operational environment that may critically impact battle space awareness. In the IPB process, MSI is useful in determining maneuverability and possible areas of enemy concealment and operations.

SYSTEM LIMITATIONS

While satellites can provide the Army many valuable capabilities, planners and users must understand some of their general limitations. Though not all-inclusive, the following limitations represent areas that must be considered when planning and requesting space support.

ACCESS

Launch operations are complex, time-consuming, manpower-intensive, and costly, For these reasons, military satellites are national resources supporting the NCA, CINCs, other services, and tactical users. As a result, requirements may exceed system capacity and capabilities. A validation process to determine what requirements will be satisfied is based on priority and system availability. Potentially, this process limits the Army's accessibility to satellite capabilities. Not only are these systems limited, most are owned, controlled, or dedicated to exclusively supporting other missions and may not be available to support Army requirements. Furthermore, many satellites do not provide direct links to the ultimate user, often requiring significant processing time by a third party to convert data into usable media. This conversion further delays distribution to Army users. As a result of having limited access, Army planners should explore the use of commercial space systems when developing military operations plans.

VULNERABILITY

Satellites are designed to survive the harsh space environment and have a degree of hardiness that many ground systems do not have. While in orbit, they may be affected by temperature extremes, radiation, solar flares, meteoroids, and space debris. Imaging systems used for reconnaissance can be affected by clouds, fog, and smoke.

METT-T affects employment of satellite ground terminals. They are also affected by line-of-sight disruptions such as high foliage areas, low take-off angles, placement in fringe areas of coverage, high usage in small and close areas, and susceptibility to whatever military capability—such as destruction, denial, disruption—an enemy force may have to use against any other ground system in the area of operation. The ground control and user segments represent the most likely targets for an adversary. When planning the use of satellite systems, the planner must consider alternatives in the event these systems are lost .

Satellites can be attacked, but they are not easy targets. Russia has demonstrated a limited capability to attack and destroy satellites in low earth orbit. Jamming satellite systems or the link between the satellite and the ground segment of the system is also a threat. Not lost on Operations Desert Shield/ Storm observers was how much dependence was placed on the use of satellite systems, Therefore, jam-resistant satellite capabilities such as Milstar must become the backbone of our satellite systems. Also imperative is that the Army should place more emphasis on influencing their design and survivability. Military use of commercial satellites must be expanded; however, risk as well as benefits must be considered, given the vulnerability of these systems.

UTILITY

Operationally, the Army is dependent upon systems currently in orbit, although these systems may or may not be suited to a particular Army mission. Many satellites do not provide continuous coverage; for example, Landsat sensors revisit equatorial points on the earth approximately every 16-18 days. Moving a satellite to a more advantageous orbit or position takes time and is limited to the amount of fuel on board since satellites cannot be refueled. Satellites are normally built with a high degree of survivability and redundancy, but once damaged or having experienced component failure, their utility and reliability are degraded. Furthermore, they are difficult to repair.

Generally, the orbital characteristics of a space system are related to the function of the satellite (see Figure 4-5). Satellites may be at a relatively fixed altitude (circular orbits) or vary in altitude (elliptical orbits). Low orbits, being closer to the earth, best support sensing requirements. The disadvantage of a low orbit is a limited view of the earth and a relatively short time over any particular location. As altitude increases, the field of view increases, but the ability to resolve small objects decreases.

Another factor affecting the use of satellites is inclination—the angle the satellite's orbital plane makes with the earth's orbital plane. A higher inclination generally means that more of the earth is covered. For example, a satellite in polar orbit (90 degrees inclination) will observe the entire globe as the earth rotates through the orbital plane. Inclinations from 0 to 90 degrees cover increasingly higher latitudes for low-altitude satellites. The length of time between satellite coverage of a particular location (that is, revisit time) depends upon the number of satellites in

For updated graphic click here.

a constellation and the capabilities of the payload, such as direct versus slant view, type of frequency, band width, data transmission rates, and sensor footprint size.